EXHIBIT A

Failure Analysis of Chart MVE 808AF-GB Cryopreservation Tank Serial Number CAB2112020013

Pacific Fertility Center Litigation

United States District Court
Northern District of California
San Francisco Division

Case No. 3:18-cv-01586-JSC

Date of Incident: Sunday, March 4, 2018

Location of Incident: Pacific Fertility Center
55 Francisco Street, Suite 500, San Francisco, California 94133

Report prepared by:

Anand David Kasbekar, Ph.D.

File No. 1780

November 6, 2020

Background

In January of 2012 the subject Chart Inc. model MVE 808AF-GB Cryopreservation Tank (Serial Number CAB2112020013) was purchased by Pacific Fertility Center (PFC) in San Francisco, CA through Praxair, Inc., a Chart distributor (see Figure 1).[1] The PFC laboratory is operated by Prelude Fertility, Inc. and its subsidiary Pacific MSO LLC. Prelude runs a network of fertility clinics and embryo and egg storage facilities throughout the United States. The subject tank known as "Tank #4" had been placed in service on March 6, 2012,[2] and according to Chart, the tank had an expected service life of 10 years.[3,4] Tank #4 was being used to store vitrified eggs and embryos from 608 IVF clients.[5]

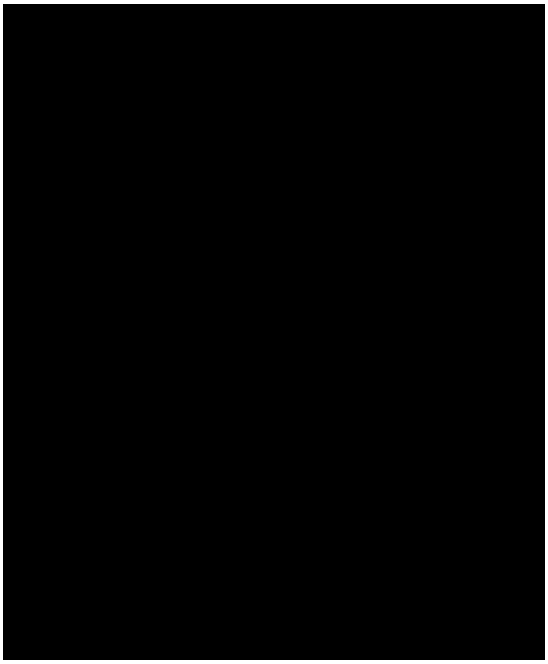

Figure 1: [redacted]

On Sunday March 4, 2018 at approximately 12:30 p.m., laboratory staff at PFC discovered that the liquid nitrogen (LN_2) refrigerant level in the subject Chart Cryopreservation Tank had been below a safe level for an undetermined period.[6] Lab Director Dr. Conaghan had turned on the autofill for Tank #4 via its electronic controller and then attempted to remove the tank lid

[1] MSO001982 (20180323 PFC Response to CAP Requests and Exhibits 1-12) at MSO001986; 2019-09-10 Deposition of Alden Romney 94:17-95:9.
[2] MSO001982 (20180323 PFC Response to CAP Requests and Exhibits 1-12) at MSO001986.
[3] CHART001432 (Intended Use Characteristics).
[4] 2020-01-14 Deposition of Justin Junnier 45:18-25
[5] MSO001982 (20180323 PFC Response to CAP Requests and Exhibits 1-12) at MSO001987.
[6] 2019-09-10 Deposition of Alden Romney 105:14-106:11; 2019-10-09 Deposition of Joseph Conaghan 40:15-25.

within two minutes of doing so in order to measure the level of liquid nitrogen in the tank.[7] Dr. Conaghan "had difficulty removing the tank from the lid" but another embryologist present, Jean Popwell, was able to remove it within one minute of his attempt "with some extra muscle."[8] Dr. Conaghan described the lid as jammed.[9] He looked for ice build-up around the lid that might explain the difficulty removing it but found none, and he thinks something other than ice caused the difficulty.[10] Dr. Conaghan does not recall seeing condensation on Tank #4 at the time but noted "there was a little water on the floor" under and around the tank.[11] Dr. Conaghan is not aware of any means for water to have been present on the floor other than via condensation and has stated that there could have been condensation on the tank in a place that he did not see, such as on the bottom.[12] Testimony provided by clinic staff indicates there was an absence of notable moisture or frost on the exterior of the tank in the days leading up to catastrophic tank failure and that the only indication of moisture was on March 4, 2018 which lead to the detection of the Tank 4 issue.[13,14,15,16,17,18,19,20] Following the removal of the jammed lid, the LN_2 level was found to be at most approximately 1 inch based upon the frost line location on the dipstick used to measure the level.[21] This measurement was taken after activation of the autofiller, and according to Dr. Conaghan, it was possible that the tank had been completely empty.[22] At some point after the tank was opened, Dr. Conaghan noticed that the metal interior wall was "puckering," and this deformation worsened over time, culminating in the extensive interior tank deformation as photographically documented the next morning (see Figures 2-3).[23,24,25]

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[7] 2019-10-09 Deposition of Joseph Conaghan 43:14-15, 101:12-21.
[8] 2019-10-09 Deposition of Joseph Conaghan 40:19-20; 101:22-102:1, 105:13-18.
[9] 2019-10-09 Deposition of Joseph Conaghan 151:20-21.
[10] 2019-10-09 Deposition of Joseph Conaghan 100:25-101:6.
[11] 2019-10-09 Deposition of Joseph Conaghan 115:18-116:5.
[12] 2019-10-09 Deposition of Joseph Conaghan 136:22-25; 137:18-21.
[13] 2019-09-10 Deposition of Alden Romney 98:20-24, 117:7-14.
[14] 2020-09-09 Deposition of Joseph Conaghan 102:7-16, 122:12-23, 211:21-213:2
[15] 2019-10-09 Deposition of Joseph Conaghan 94:5-95:7, 135:12-136:9
[16] 2020-08-27 Deposition of Erin Fischer 50:6-8
[17] 2020-08-31 Deposition of Gina Cirimele 64:15-65:1, 66:25-67:10, 69:21-70:9, 72:6-17, 74:7-18, 117:14-23, 129:16-130:10
[18] 2020-08-28 Deposition of Jennifer Andres 43:9-18, 45:8-46:6
[19] 2020-09-02 Deposition of Jean Popwell 31:12-32:3, 60:1-25, 119:1-10, 121:3-12, 122:24-123:12, 128:24-129:10
[20] 2020-09-29 Deposition of Hana Lamb 28:6-14
[21] 2019-10-09 Deposition of Joseph Conaghan 112:6-12;. 2020-09-09 Deposition of Joseph Conghan 207:12-208:16.
[22] 2019-10-09 Deposition of Joseph Conaghan 112:13-113:8.
[23] 2019-10-09 Deposition of Joseph Conaghan 114:10-20.
[24] 2019-10-09 Deposition of Joseph Conaghan 117:13-23.
[25] MSO001982 (20180323 PFC Response to CAP Requests and Exhibits 1-12) at MSO001994-1997; 2019-10-09 Deposition of Joseph Conaghan 41:19-24.

Embryologist Jennifer Andres also testified to seeing a buckle or outward bump in the inner wall of the tank.[26]

Figure 2: [redacted]

Figure 3: [redacted]

As a result of the failure of the subject tank, stored eggs and embryos were more likely than not exposed to elevated temperatures. The tank failure and resulting deformation likely delayed recovery efforts by inhibiting removal of the tank lid. At the time of this incident PFC reports that there were 1,500 eggs and 2,500 embryos from the 608 IVF clients stored in the subject tank.[27] At some point after the incident, the controller, which includes an auto-fill mechanism, was removed from Tank #4. Both the tank and controller were transported from the fertility clinic to Exponent's Menlo Park Facility on March 8, 2018 (see Figure 4).

[26] 2020-08-28 Deposition of Jennifer Andres 53:5-22.
[27] MSO001982 (20180323 PFC Response to CAP Requests and Exhibits 1-12) at MSO001986-1987.

Figure 4: [redacted]

The original installation of the subject tank included the previously discussed automated controller and an integrated alarm system designed to maintain and provide 24x7 monitoring of tank temperature and liquid nitrogen levels and alert staff by telephone in the event of a problem (see Figure 5). PFC indicated that sensors for the monitoring system "are connected to a telephone alarm system that will alert staff to an alarm condition outside of normal working hours. . . .The alarm system is tested weekly and continues to run on battery power in the event of a power failure. The alarm system can also be checked remotely."[28] When a tank alarm goes off, the on-call embryologist is supposed to arrive within 30 minutes regardless of time of day and must conduct a physical inspection of the tank before the alarm can be turned off.[29] [redacted] and for this reason PFC chose to "mute" the alarm and disconnect the controller from the autodialer system that would normally have alerted the staff of a problem.[30] These automated systems were disabled on February 15, 2018,

[28] Sperm and Embryo Freezing, Pacific Fertility Center, www.pacificfertilitycenter.com/treatmentcare/sperm-and-embryo-freezing 9-24-2019
[29] *Id.*
[30] MSO001982 (20180323 PFC Response to CAP Requests and Exhibits 1-12) at MSO001985-1986.

approximately 17 days prior to the March 4, 2018 incident.[31,32]

Figure 5:

The control panel was only activated when the tank had to be filled with liquid nitrogen. As of the date of the incident, PFC had not replaced the controller on Tank #4 and had shifted to manual monitoring of the tank.[35] Further, I understand that the controller was inspected and load testing of the controller was completed on October 13, 2020, during which the controller continued to malfunction as described above.

[31] MSO001982 (20180323 PFC Response to CAP Requests and Exhibits 1-12) at MSO001986.
[32] 2019-10-09 Deposition of Joseph Conaghan 72:13-16.
[33] 2019-10-09 Deposition of Joseph Conaghan 187:18-24.
[34] 2019-10-09 Deposition of Joseph Conaghan 187:18-24 and 93:11-19
[35] 2019-10-09 Deposition of Joseph Conaghan 89:22-90:4 and 93:11-19
[36] MSO024140-41
[37] MSO001314 (4/23/2018 Chart Recall Notice).

the potential for a sudden vacuum seal leak or failure. Chart also has a history of MVE Controller malfunctions that date back to at least 2016, over 2 years prior to the date of the PFC incident.[38,39,40,41,,42, 43, 44]

[redacted]

In early April 2018, Plaintiffs' counsel, representing individuals whose material was stored in Tank #4, requested my assistance in evaluating the current condition of the subject Chart Cryopreservation Tank and investigating the cause of the tank failure. This report outlines my efforts to date along with my findings and opinions.

Materials Reviewed

Reviewed file materials include the following:

1. 2018-05-30 Complaint
2. 2019-09-18 Second Amended Consolidated Class Action Complaint
3. 2020-07-21 Third Amended Complaint
4. 2018-09-14 &18 Protective Orders
5. MVE Cryopreservation for Life Science Catalog – Brochure
6. CHART 000001-000126 (Chart Tank Drawings and Specifications)
7. CHART000058 – 60 (2012-01-24 Tank QC and Shipping)
8. CHART000918-1050 (2010-08 Tank and TEC 3000 Manual)
9. CHART001432 (2006-03-01 DFMECA - CRYO-RA-001 L)
10. CHART005674-005675 (Risk Assessment)
11. CHART008310 – CHART008320
12. CHART008455 (Emails RE-MVE Controller Problems in Europe)
13. CHART008490 – CHART008498

[38] CHART008455, CHART010131, CHART025664, and EXTRON-002060
[39] Defendant Chart, Inc.'s Answers to Plaintiffs' Interrogatories (Set 7) and to Plaintiffs' Request for Admission (Set 5) Answers 4, 5
[40] CHART026003.
[41] CHART034331.
[42] 2019-10-09 Deposition of Joseph Conaghan 72:5-12.
[43] CHART054154
[44] Defendant Chart, Inc.'s Answers to Plaintiffs Requests for Admission (Set 5) Answers 4,5,7,8,9.

14. CHART008504
15. CHART005093 – CHART005099
16. CHART009354 – CHART009361
17. CHART009446 – CHART09451
18. CHART009453
19. CHART009455
20. CHART009518 (Catalog ML-CRYO0009 H 13b)
21. CHART010131 (2018-03-15 - Tech3000 Improvement Project 3_15_18)
22. CHART016303 – CHART016536
23. CHART025664 (No Back EMF Protection)
24. CHART026003 (2015 Field Service Email)
25. CHART031908 – CHART031909 (TEC 3000 Manual Event Codes User Defined Alarms)
26. CHART034331 (2015 Field Service Email)
27. CHART035767 – CHART035768
28. CHART050770
29. CHART054154
30. CHART057093 – CHART057099
31. CHART058497 – CHART058503
32. CHART069993
33. CHART069995
34. CHART069999
35. CHART070032 – CHART070034
36. CHART070144 – CHART070147 (Chart Test Report 828 – Pumpout Port Blowout Testing from 2017-11-27)
37. CHART070358 – CHART070364
38. CHART070444
39. CHART070503 – CHART070558
40. Chart MVE 1839AF-GB Tank Implosion Correspondence
41. EXTRON-002060
42. MSO001314 (2018-04-23 Chart Recall Notice)
43. MSO001982-2220 (2018-03-23 PFC Response to CAP Request and Exhibits 1-12)
44. MSO012832 (2018-03-13 Letter from Joe Conaghan to CA Dept of Health)
45. MSO012835 (2018-03-13 Letter from Joe Conaghan to College of American Pathologists)
46. MSO021089-21250 MVE TEC 3000 Tech Manual (Rev G)
47. MSO024140-41
48. PRELUDE 002283-002285 (2018-03-08 Email Correspondence from Yelena Pasman to Suzan Hertzberg)
49. MSO023987 (Photograph of Exemplar Tank Interior with Rack and Vials in Place)
50. Christopher Brand Report Dated 2020-01-10
51. Keith Gustafson Report Dated 2020-01-10
52. 3D_Scan_Data Collected 2019-10-01 & Rcvd 2019-11-07
53. Exponent Vacuum Plug Removal Documentation
54. Exponent Keyence Images_Tank_Interior Collected 2019-10-01 & Rcvd 2019-11-07

55. Exponent Photographs & Video and of Vacuum Plug 2018-03-19
56. Exponent X-Ray of Tank 2019-11-25 Rcvd 2019-12-30
57. Data and Images from Exponent March 2020 Inspections and Subsequent Metallurgical Testing
58. 2020-0728 Anamet Laboratory Certificate
59. 2019-10-15 Expert Reports of S. Somkuti, C. Allen, and N. Jewell
60. Discovery Responses
    a. Chart Supplemental Answers to Plaintiffs Interrogatories Set 5 and Cryo Welder Equipment List
    b. Chart 2nd Supplemental Answers to Plaintiffs Interrogatories Set 5 and Cryo Welder Equipment List
    c. Chart Answers to Plaintiffs Interrogatories 2020-08-25 Set 6
    d. Chart Answers to Plaintiffs Interrogatories 2020-09-05 Set 7
    e. Chart Answers to Plaintiffs Requests for Admission 2020-05-27 Set 3
    f. Chart Answers to Plaintiffs Requests for Admission 2020-08-25 Set 4
    g. Chart Answers to Plaintiffs Requests for Admission 2020-09-05 Set 5
61. Depositions
    a. 2019-08-14 Jeffrey Dresow
    b. 2019-08-21 Gregory Mueller
    c. 2019-08-21 William Pickell
    d. 2019-09-10 Pacific MSO and Alden Romney
    e. 2019-09-18 Frank Bies
    f. 2019-10-09 Pacific MSO and Joseph Conaghan
    g. 2019-12-13 Anand Kasbekar
    h. 2020-01-14 Justin Junnier
    i. 2020-01-16 Christopher Brand
    j. 2020-01-23 Jeff Brooks
    k. 2020-02-06 Keith Gustafson
    l. 2020-02-18 Ramon Gonzalez
    m. 2020-02-20 Brendon Wade
    n. 2020-02-21 Keith Gustafson
    o. 2020-08-27 Erin Fisher
    p. 2020-08-28 Jennifer Andres
    q. 2020-08-28 Katherin Buchanan
    r. 2020-08-31 Gina Cirimele
    s. 2020-09-02 Jean Popwell
    t. 2020-09-02 Jinnuo Han
    u. 2020-09-09 Pacific MSO and Joseph Conaghan
    v. 2020-09-11 Seth Adams
    w. 2020-09-29 Hana Lamb
    x. 2020-10-05 Buster Ingram
    y. 2020-10-08 Kyle Eubanks
62. Video of 2020-10-13 Chart production facility inspection
63. Sperm and Embryo Freezing, Pacific Fertility Center, www.pacificfertilitycenter.com/treatmentcare/sperm-and-embryo-freezing 9-24-2019
64. ASM Handbook Volume 11 Failure Analysis and Prevention, Copyright 2002
65. ASM Handbook Volume 12 Fractography, Copyright 1987.

66. Los Alamos National Labs Engineering Standards Manual ISD 341-2 Chapter 13 Welding & Joining
67. Journal of Failure Analysis and Prevention Volume 5(2) April 2005, ASM International p. 11-15
68. A. Griebel Technical Brief: Fatigue Dimples, Journal of Failure Analysis and Prevention Volume 9 2009, ASM International
69. Welding Innovation Vol. XVI, No. 2, 1999
70. A Review of The Application of Weld Symbols on Drawings, https://www.twi-global.com/technical-knowledge/job-knowledge/weld-symbols
71. Cruxweld Basic Welding Symbols Explained
72. https://priodeep.weebly.com/uploads/6/5/4/9/65495087/welding_2.pdf
73. www.weldingtipsandtricks.com/full-penetration-weld
74. D. Hull, Fractography Observing, Measuring, Interpreting Fracture Surface Topography, Cambridge University Press, 1999
75. ASM Metals Handbook Volume 9 8th Edition Fractography and Atlas of Fractographs
76. G. Pantazopoulos, A Short Review on Fracture Mechanisms of Mechanical Components Operated under Industrial Process Conditions: Fractographic Analysis and Selected Prevention Strategies, Metals 2019, 9, 1480.
77. ASM International Failure Analysis Committee, Handbook of Case Histories in Failure Analysis, Volumes 1 & 2

In addition to reviewing the above materials, I have also had the opportunity to conduct an inspection of the Pacific Fertility Center, the subject Tank #4, and the associated controller. Those inspections included leak testing, non-destructive testing, destructive disassembly, CT evaluation of critical welds, metallography, and fractography. I have also examined an unused MVE 808 tank that was purchased new in October 2020 and have had the opportunity to participate in a virtual inspection of Chart's facility where the subject tank was manufactured. That virtual inspection included viewing aspects of the manufacturing process for a different model cryogenic tank than the subject MVE 808.

Description of Work Performed

I conducted an inspection of Pacific Fertility Center located at 55 Francisco Street in San Francisco, CA on September 24, 2018. That inspection consisted of visually examining, photographing, and videotaping the laboratory area where the Chart model MVE 808AF-GB Cryopreservation Tank had been located at the time of the incident on March 4, 2018. The subject tank itself was no longer at PFC and was inspected at the Menlo Park offices of Exponent on September 25, 2018. The first tank inspection was limited to visually examining and

photographing the tank, the tank lid, the previously removed MVE TEC 3000 controller, and the previously disassembled vacuum port plug assembly. The interior of the tank bottom was not accessible at the time of this inspection. The underside of the tank also could not be inspected, and the interior tank bottom could not be examined without destructive removal of the tank's false bottom. Although no testing was done during that tank inspection, Defendants' consultant, Exponent, had previously conducted leak testing, digitization, and cleaning of the subject tank and tank cover.

[redacted]

[redacted]

Figure 6: A [redacted]

[45] CHART000073 (False Bottom Dwg A9570)

Figure 7: [redacted]

Figure 8: [redacted]

Figure 9

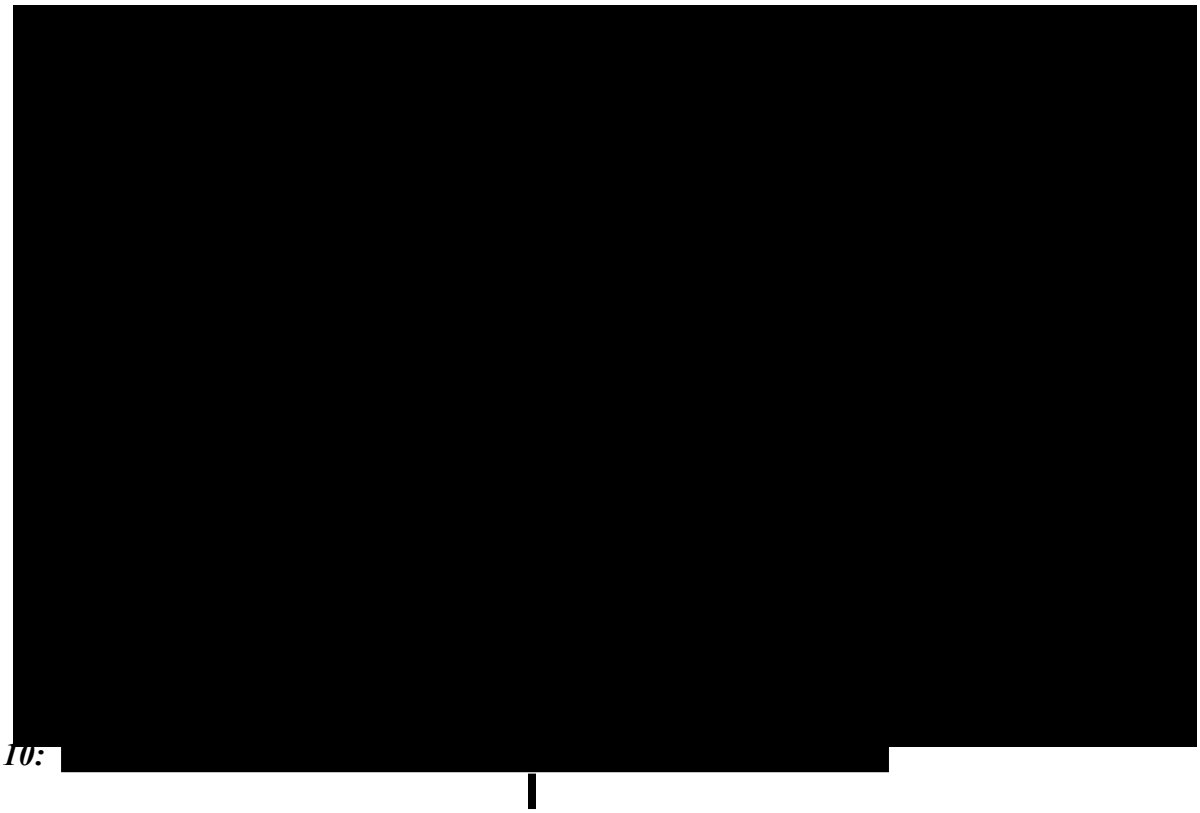


Figure 10:

Figure 11: [redacted]

Figure 12: [redacted]

Figure 13: [redacted]

A Keyence VHX 2000 Digital Microscope fixed to a boom arm was used to more closely examine the leak area that was detected along the lower edge of the welded fill port. That microscope along with the use of a portable handheld microscope revealed a substantial crack in the weld of the fill port (Figures 18-20). The digital microscope was used to view the cracked annular weld and collect magnified video which clearly and definitely showed the crack to be the leak location as bubbles within the soap solution could be seen emanating directly from the crack (Figures 21-22). This circumferential crack was clearly visible at about a 20X magnification between approximately the 4 o'clock and 8 o'clock positions. In order to further check for cracks and better evaluate the observed crack, non-destructive testing (NDT) was conducted using Magnaflux Spotcheck liquid dye penetrant. The NDT further confirmed the presence of the circumferential crack in the annular weld that secured the fill port fitting to the inner tank wall (Figures 23-24). No other breaches or leaks could be identified between the tank interior and the vacuum space

Figure 14: [redacted]

Figure 15: P [redacted]

Figure 16: C

Figure 17:

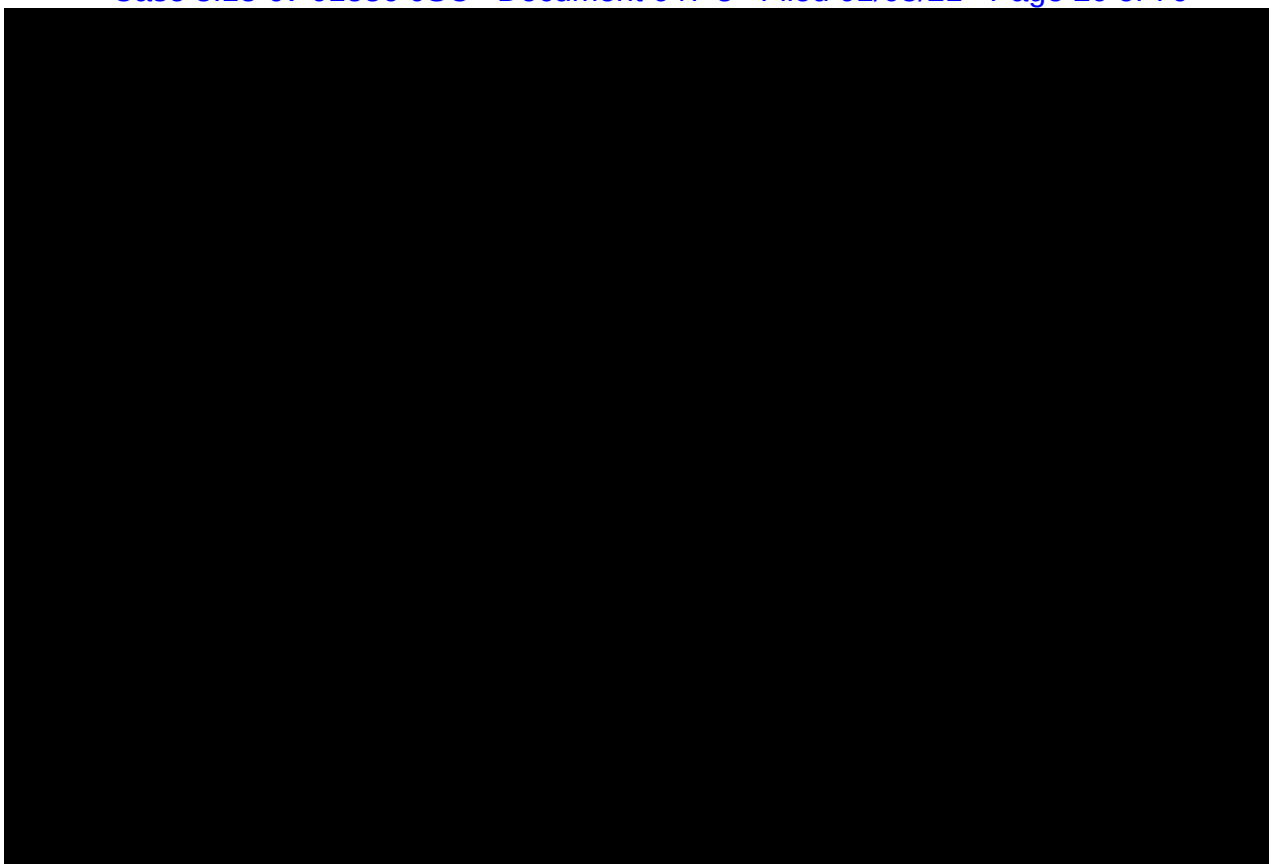


Figure 18:

Figure 19: [redacted]

Figure 20: [redacted]

[redacted]

[redacted]

[redacted]

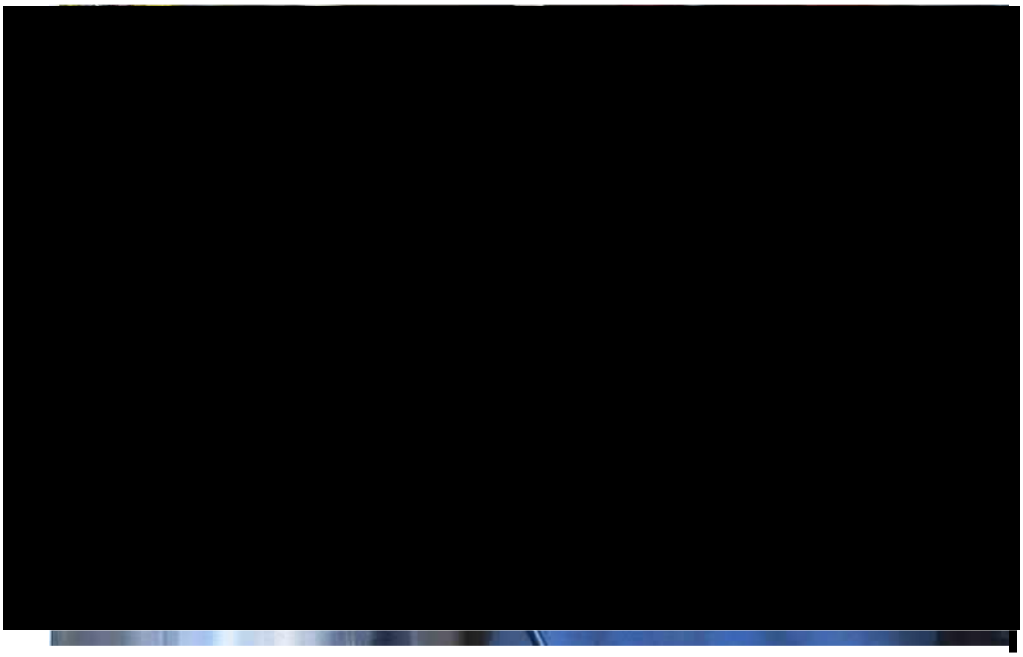
[redacted]

[46] Defendant Chart, Inc.'s Answers to Plaintiffs Requests for Admission (Set 5) Answer 17.

[redacted]

[redacted]

Figure 21: [redacted]



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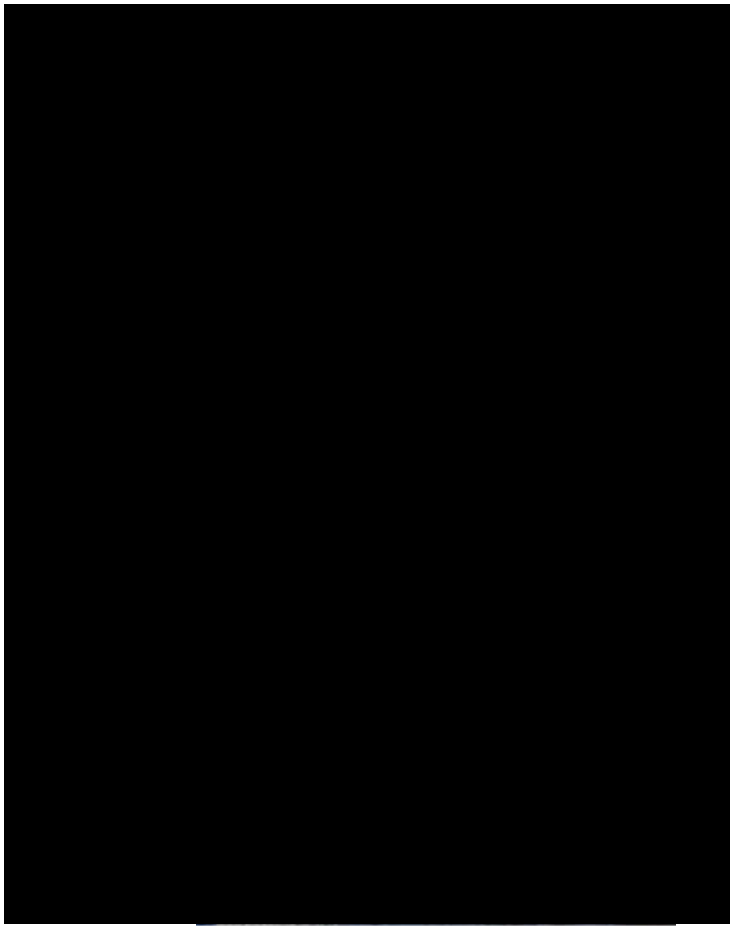

Figure 23: [redacted]

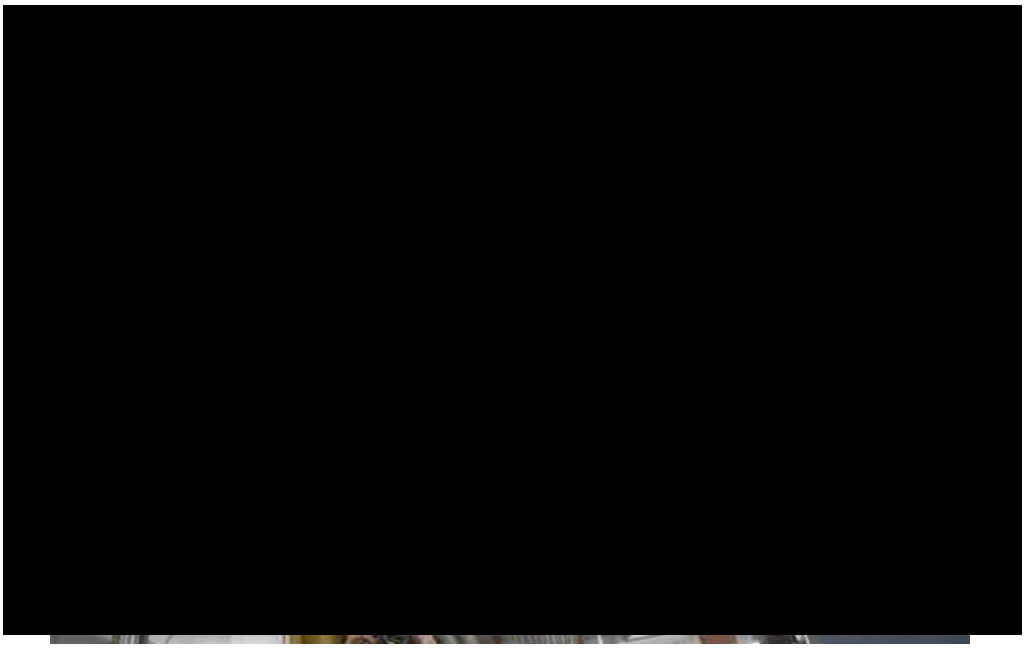

Figure 24: [redacted]

Figure 25: [redacted]

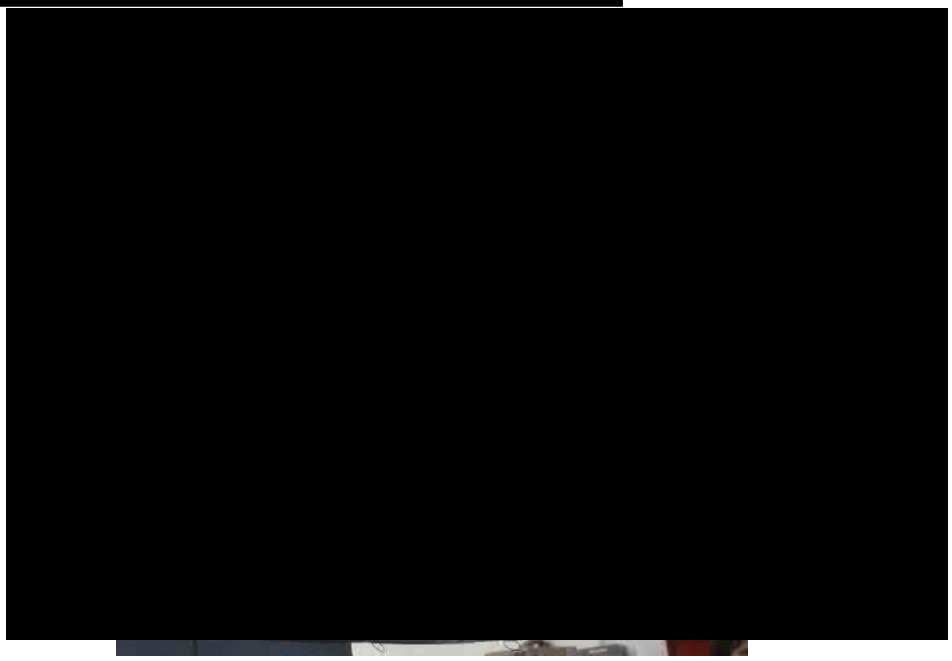

Figure 26: [redacted]

Figure 27: [redacted]

Figure 28: [redacted]

Figure 29: [redacted]

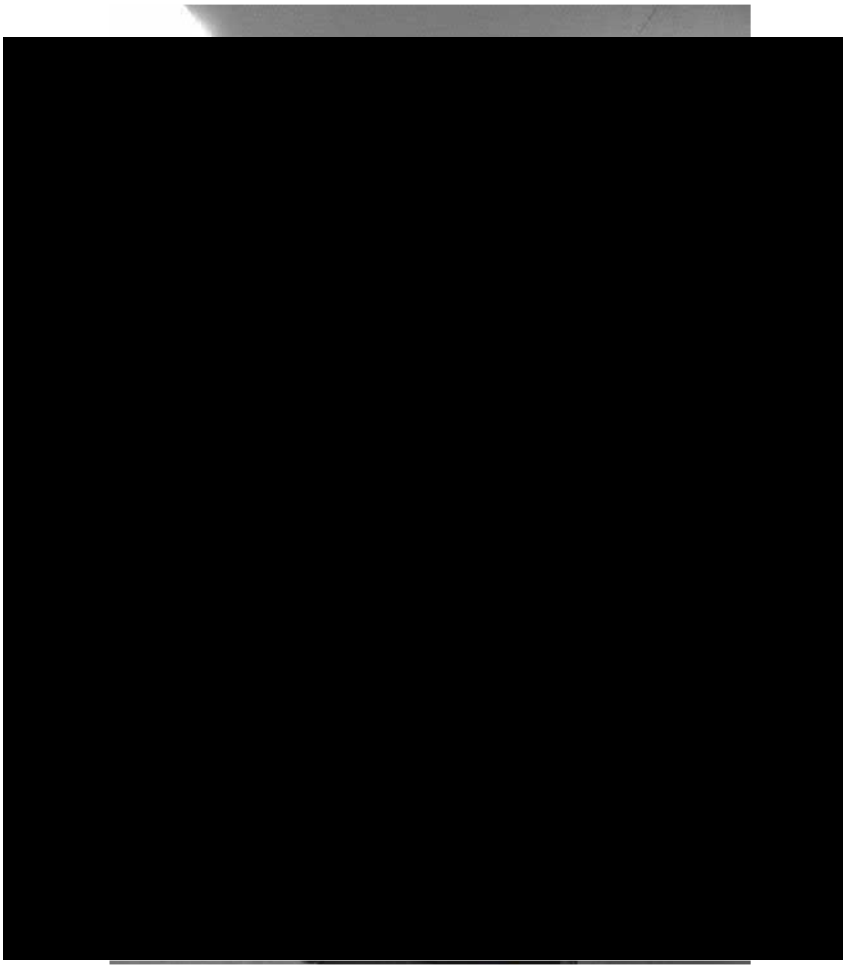

Figure 30: I

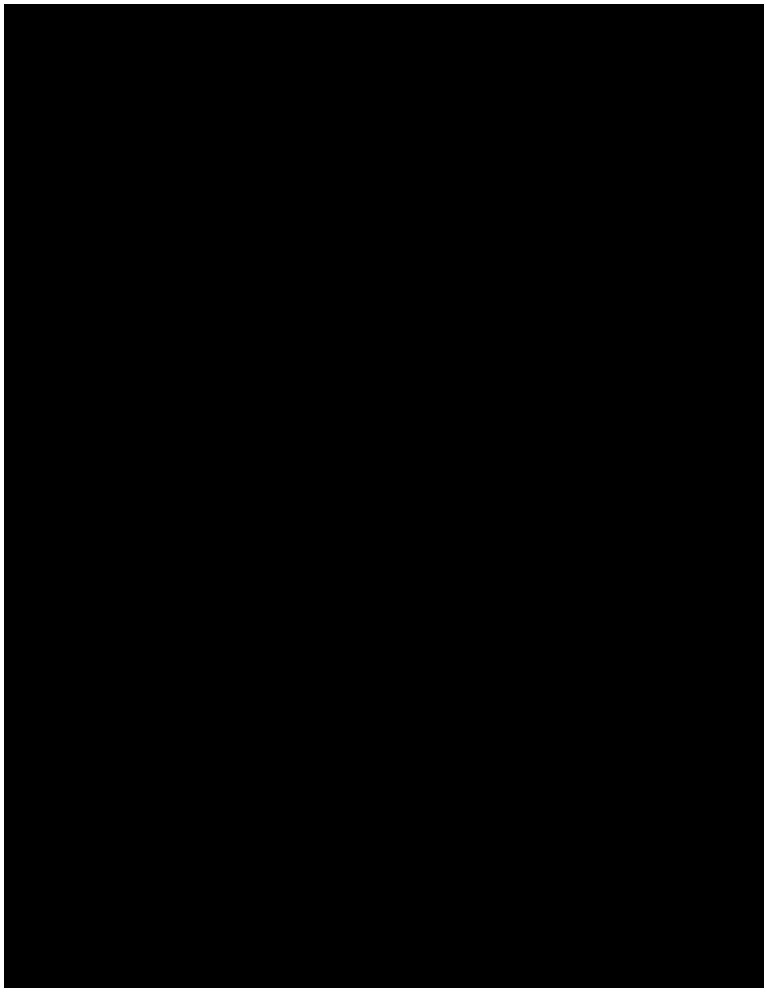

Figure 31:

Figure 3

Figure 33:

Figure 34: [redacted]

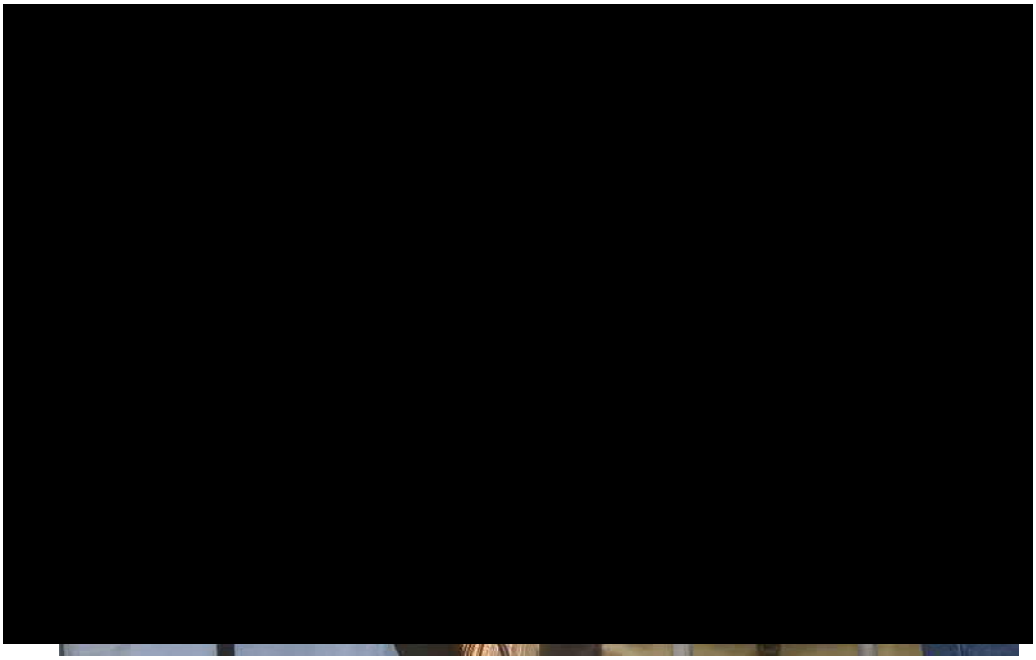

Figure 35: A [redacted]

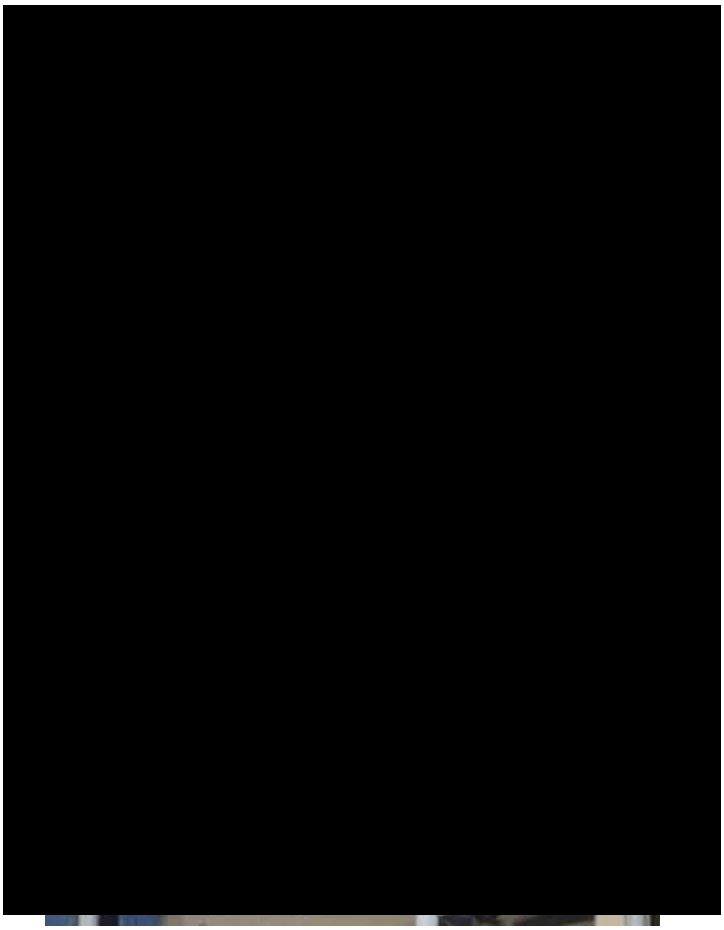

Figure 36:

Figure 37:

Figure 38:

Figure 39:

Figure 40: [redacted]

Figure 41: [redacted]

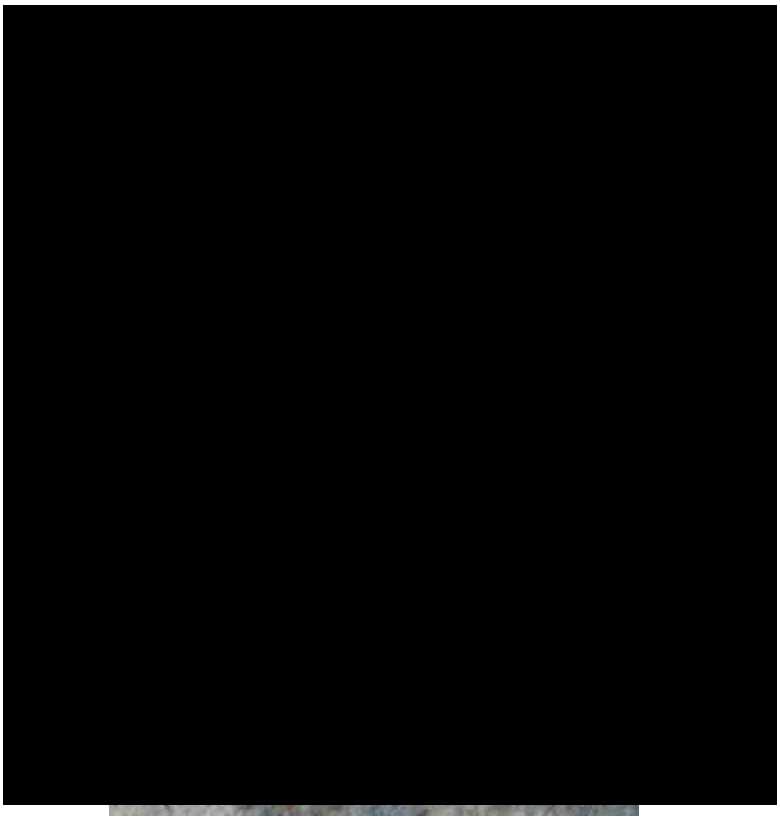

Figure 42: T

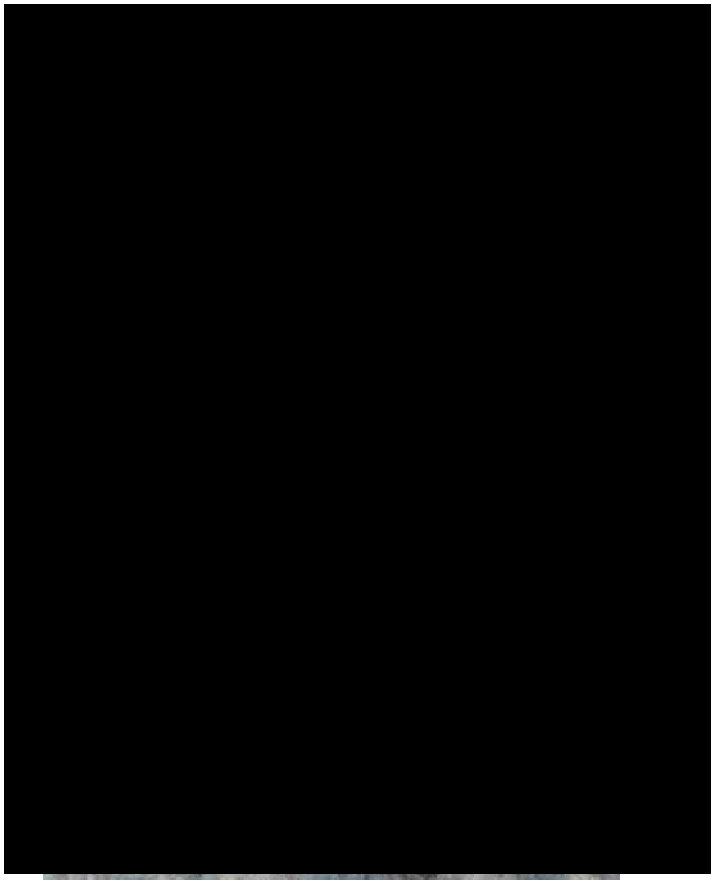

Figure 43: [redacted] ***st*** [redacted]

Figure 44: [redacted]

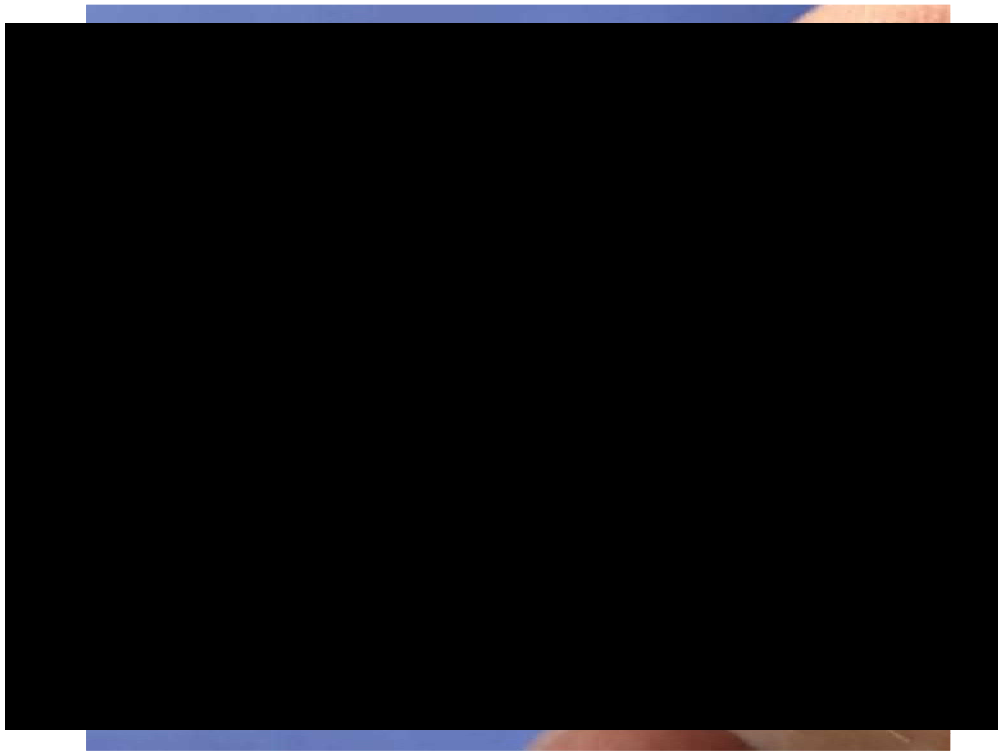

Figure 45: [redacted]

Figure 46: [redacted]**s.**

Figure 47: [redacted]

Analysis and Discussion

The specifications for the MVE 808 tank indicate an estimated full tank capacity of 230 liters of LN_2. The estimated static holding time for a full tank is 32 days with a nominal evaporation rate of 8 liters per day.[47] Nitrogen evaporation rate testing performed by Chart when the subject tank was manufactured indicates an evaporation rate of only 6.5 liters per day.[48] The subject tank was reportedly filled on Saturday, March 3, 2018 at the end of the day, which was typically 2:00 p.m. on weekends.[49] The tank failure was discovered at 12:20 p.m. on Sunday, March 4, 2018, less than 24 hours after the last fill. Based on the MVE 808 specifications and the testing performed by Chart, less than about 8 liters of LN_2 should have evaporated during this time

[47] CHART000088 (MVE 808 Spec Dwg).
[48] CHART000058.
[49] 2019-09-10 Deposition of Alden Romney 103:13-18.

period. Given a fill level of 14 inches as documented and a height to volume relationship of 10.3 inches of LN_2 per inch of fill height, the level should have decreased by less than 1 inch between the Saturday afternoon fill and the discovery of the failed tank on Sunday at 12:30 p.m.[50] This analysis also assumes that the 14-inch fill covers the tank contents by at least 1 inch.[51,52] If the tank vacuum jacket remained intact, then the LN_2 evaporation should have been immaterial. However, if a vacuum jacket breach occurred resulting in the loss of insulating ability and allowing LN_2 to enter the vacuum space, then a significant decrease in the LN_2 level would occur more rapidly than from normal evaporation.

[redacted]

[50] MSO001982 (20180323 PFC Response to CAP Requests and Exhibits 1-12) at MSO001984 - 1985 and MSO002046; CHART001038.
[51] 2019-10-09 Deposition of Joseph Conaghan 99:18-25.
[52] 2019-10-09 Deposition of Joseph Conaghan 105:25-106:21.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[53] G. Pluvinage, Fracture and Fatigue Emanating from Stress Concentrators, 2003 p. 1-3, 97
[54] ASM Handbook Volume 12 Fractography p. 112.

Figure 49: [redacted]***ents.***

[redacted]

Figure 50: S [redacted]

[redacted]

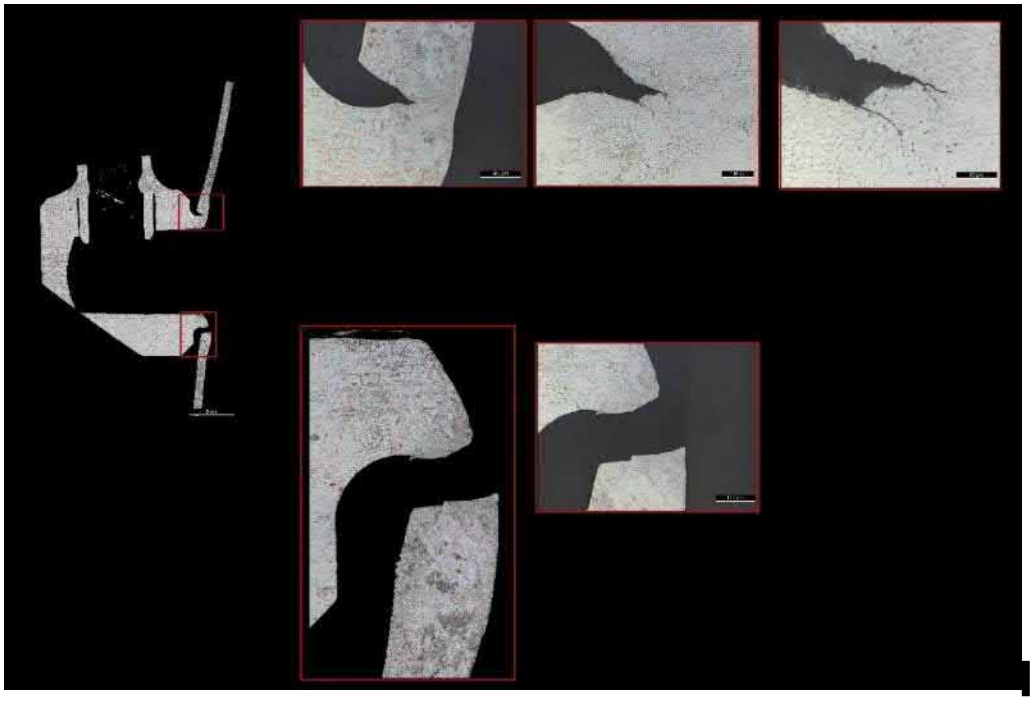

Figure 51: [redacted]

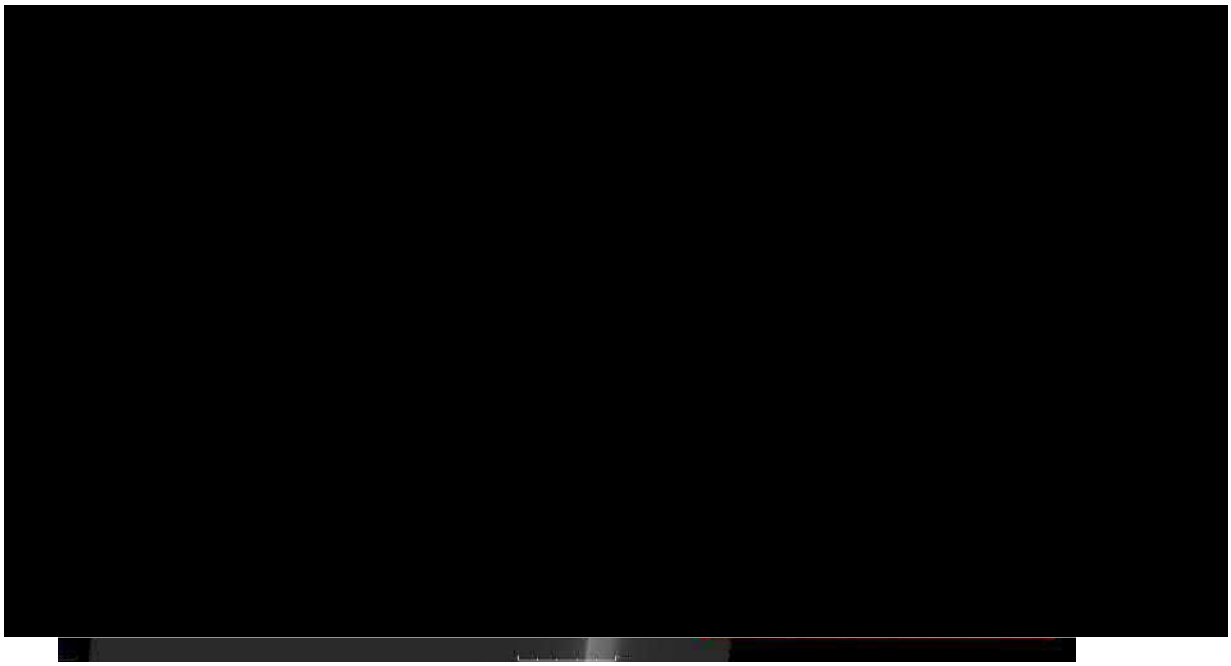

Figure 52:

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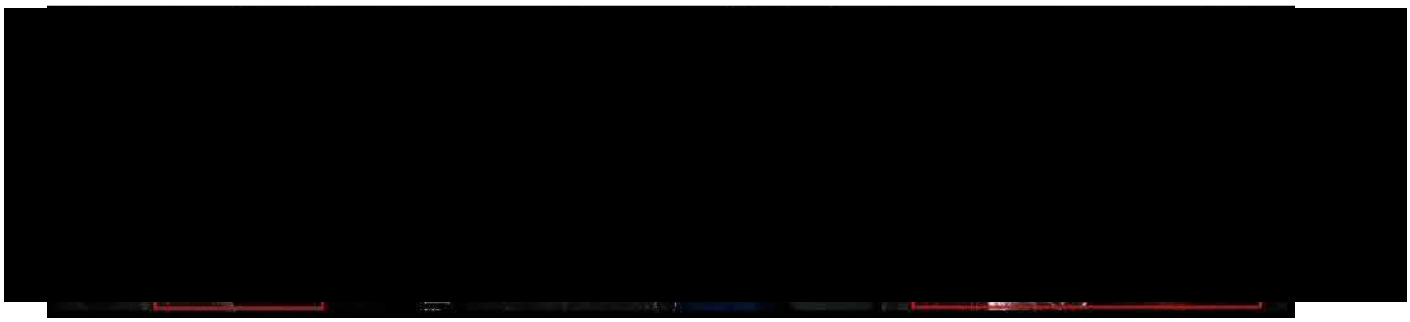


Figure 53: [redacted]

Figure 54: [redacted]

[55] Los Alamos National Labs Engineering Standards Manual ISD 341-2 Chapter 13 Welding & Joining

[redacted]

[56] ASM Handbook Volume 12 Fractography p. 112, 368.
[57] G. Pantazopoulos, A Short Review on Fracture Mechanisms of Mechanical Components Operated under Industrial Process Conditions: Fractographic Analysis and Selected Prevention Strategies, Metals 2019, 9, 1480.
[58] ASM Metals Handbook Volume 9 8th Edition Fractography and Atlas of Fractographs p. 318.
[59] Journal of Failure Analysis and Prevention Volume 5(2) April 2005, ASM International p. 11-15.
[60] ASM Handbook Volume 11 Failure Analysis and Prevention, Copyright 2002, p. 578
[61] ASM Handbook Volume 12 Fractography, Copyright 1987, p. 53
[62] A. Griebel Technical Brief: Fatigue Dimples, Journal of Failure Analysis and Prevention Volume 9 2009, ASM International p. 193-196

[redacted]

Figure 55: [redacted]

[63] ASM Handbook Volume 12 Fractography p. 111-112, 358-359.
[64] D. Hull, Fractography Observing, Measuring, Interpreting Fracture Surface Topography, Cambridge University Press, 1999, p. 332-333.
[65] L. Engel and H. Klingele, An Atlas of Metal Damage, Prentice Hall, 1981 p. 84-85
[66] ASM Metals Handbook Volume 9 8th Edition Fractography and Atlas of Fractographs p. 455.

Figure 56: B

Figure 57:

[redacted]

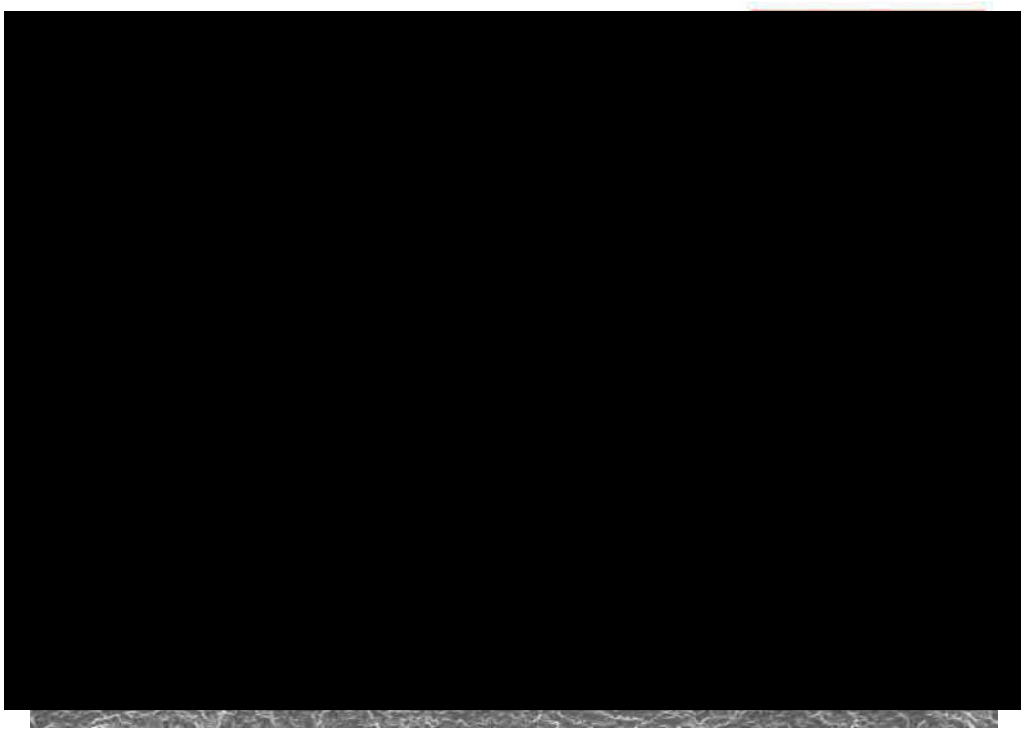


Figure 58: [redacted]

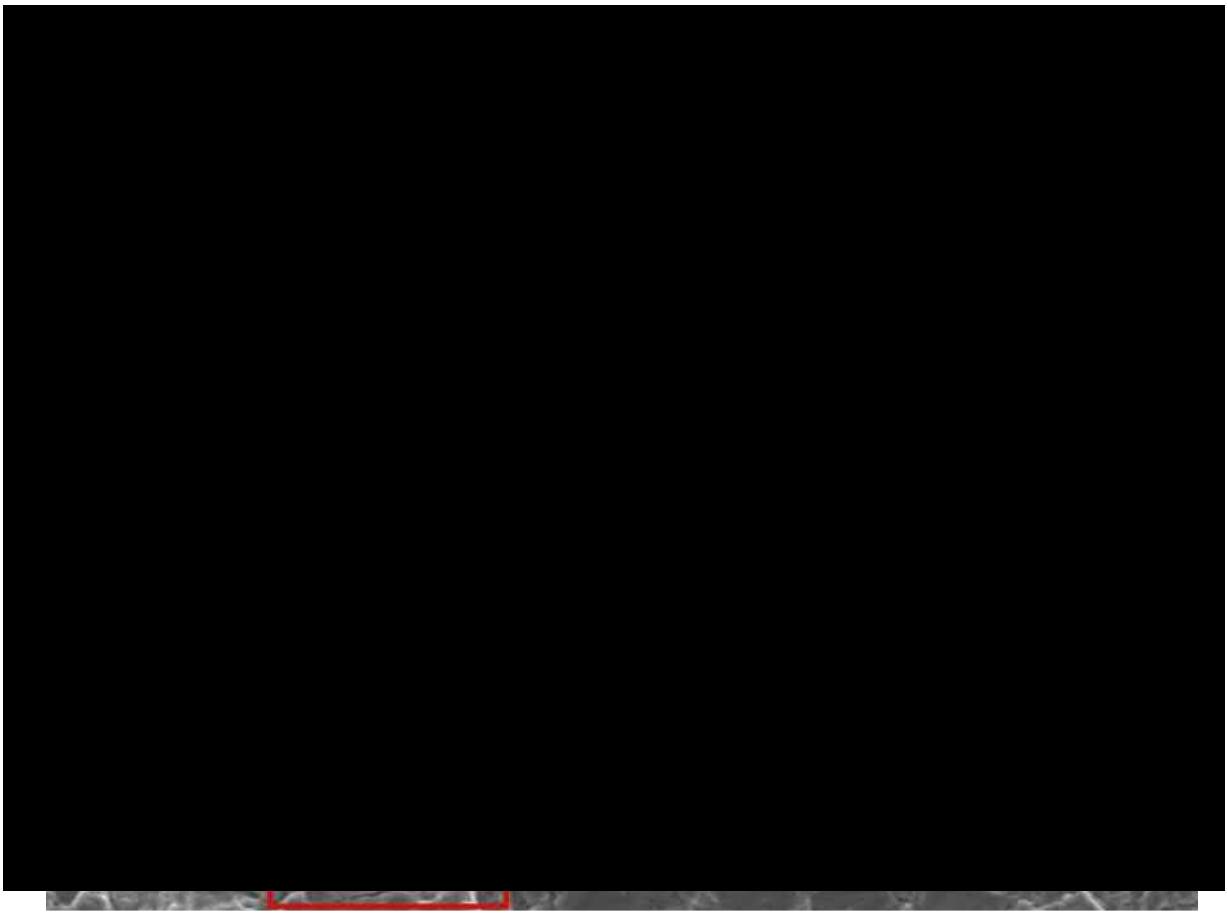


Figure 59: [redacted]

Figure 60: [redacted]

Figure 61:

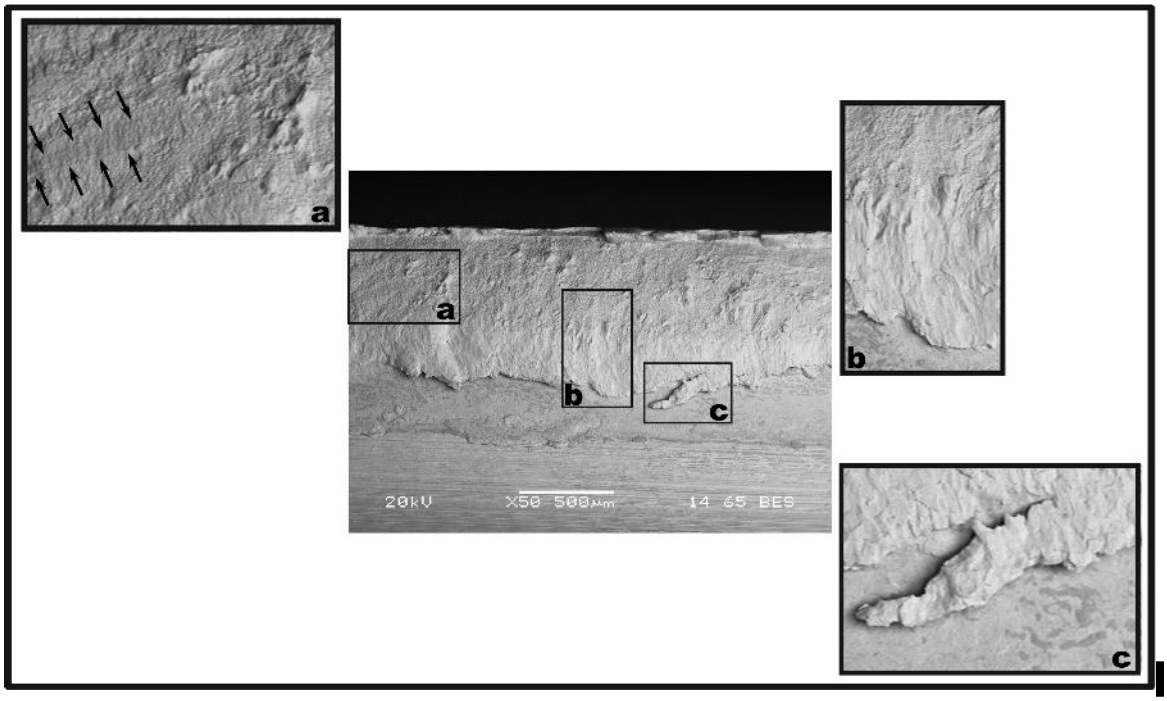


Figure 62:

Figure 63:

Figure 64:

[67] CHART000115; CHART070444; 2020-10-08 Deposition of Kyle Eubanks 47:11-47:23

[redacted]

[68] Defendant Chart, Inc.'s Answers to Plaintiffs' Requests for Admission (Set 4) Answers 5, 9; Answers to Plaintiffs' Interrogatories (Set 6), Answers 1, 4.
[69] Welding Innovation Vol. XVI, No. 2, 1999
[70] 2020-09-11 Deposition of Seth Adams 27:19-28:13.
[71] A Review of The Application of Weld Symbols on Drawings, https://www.twi-global.com/technical-knowledge/job-knowledge/weld-symbols
[72] Cruxweld Basic Welding Symbols Explained
[73] www.weldingtipsandtricks.com/full-penetration-weld

[redacted]

[redacted]

[redacted]

Figure 65: [redacted]

[redacted]

Figure 66: E [redacted]

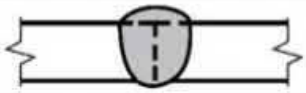
Name	Weld	Symbol
Square butt		

Figure 67: [redacted]

[redacted]

Figure 68: [redacted]

[74] https://priodeep.weebly.com/uploads/6/5/4/9/65495087/welding_2.pdf

[redacted]

Figure 69: [redacted]

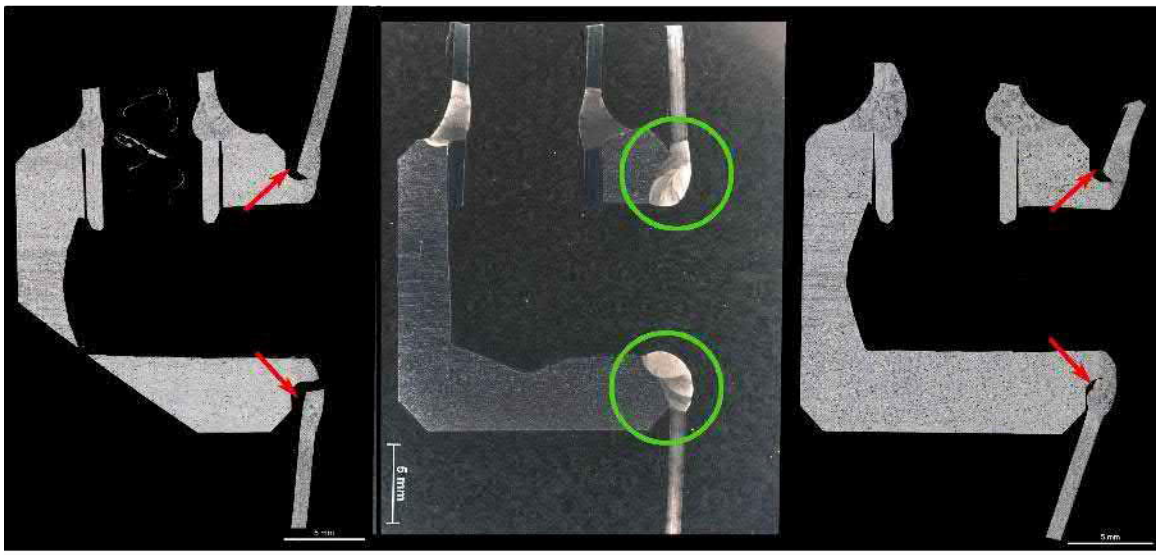


Figure 70: [redacted]

[redacted]

Figure 71: [redacted]

[redacted]

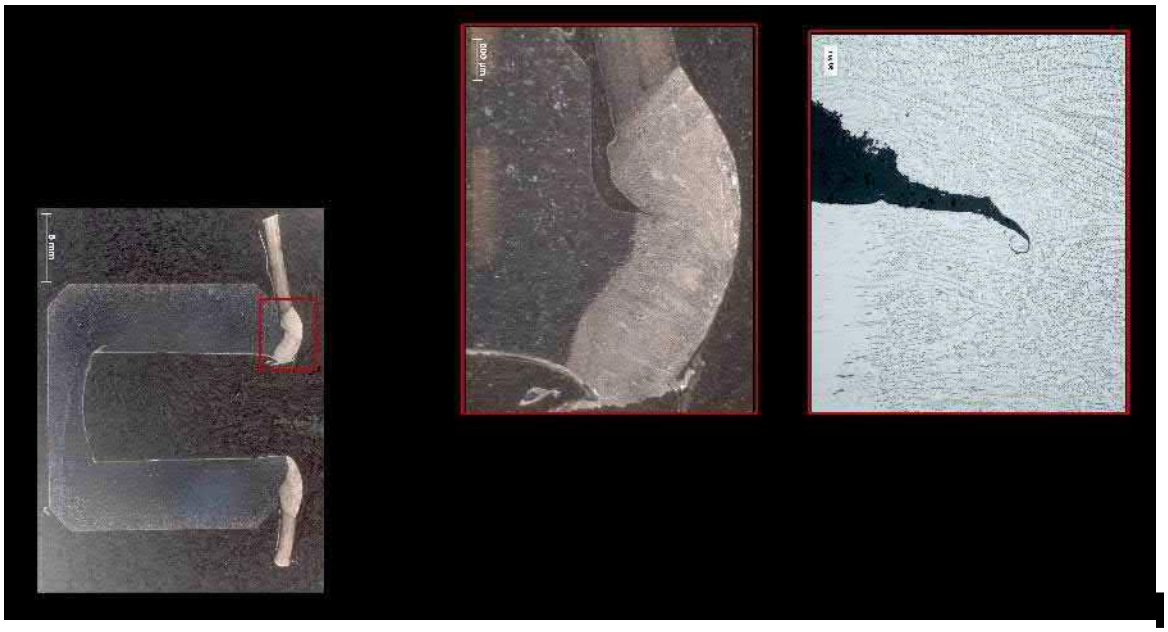


Figure 72: [redacted]

[redacted]

Figure 73:

Figure 74:

Summary of Findings and Opinions

The following is a summary of my findings and opinions based upon my training, education, and experience, along with my review of the available materials as listed above, and the multiple inspections and analyses of the subject Chart MVE 808AF-GB Cryopreservation Tank including metallurgical analysis and fractography of the failed annular weld that attached the fill port elbow to the inner tank wall. The following findings and opinions may be revised or amended as necessary should additional information become available or if additional work is performed by either party. I reserve the right to respond to other experts' testimony and to supplement my report as needed. I similarly reserve the right to respond to arguments made by the Defendants and their experts and other witnesses at trial.

1. The subject Chart tank was purchased new in January 2012 and had been in service for just over 6 years at the time of failure. The tank was only about 60% of the way through its expected service life of 10 years. PFC's experience is that tanks can and should last significantly longer than 6 years.[75,76,77,78]

2. Chart knew that its MVE Cryogenic freezers, such as the subject MVE808 tank, are used primarily for highly sensitive biotech applications including biological storage of human eggs and embryos.[79] The MVE Cryopreservation "For Life Science" brochure specifically references the storage of human cells.[80] Chart training materials state "Cryogenic freezers are used primarily for biological storage of human tissue, cord blood, bone marrow, stem cell and other highly sensitive biotech and pharmaceutical applications."[81] Product literature for the MVE Stock Series, which includes the MVE

[75] 2019-09-10 Deposition of Alden Romney 139:5-7.
[76] CHART050770
[77] 2020-01-14 Deposition of Justin Junnier 45:20-23.
[78] 2020-01-23 Deposition of Jeff Brooks 110:7-17.
[79] CHART054154
[80] MVE Cryopreservation for Life Science Copyright 2015
[81] CHART016303 (Chart/MVE Cryobiological Training 2016) at CHART0016315

808, states these tanks are "the ultimate in security for the breeding industry and are primarily used to store semen and embryos."[82, 83]

3. [redacted]

4. [redacted]

[82] MVE Cryopreservation for Life Science Copyright 2015
[83] Defendant Chart, Inc.'s Answers to Plaintiffs Requests for Admission (Set 4) Answer 13.

5. [redacted]

6. [redacted]

7. T[redacted]

[84] CHART01432 (DFMECA)
[85] CHART008310
[86] Chart's Responses to Plaintiffs' 2020-09-05 Request for Admission (Set 5) Answers 14-16.

[redacted]

8. [redacted]

9. [redacted]

10. [redacted]

[redacted][87]

11. This weld joint could have been made significantly more robust by incorporating a second weld between the vacuum space side of the inner tank wall to the mating face of the fill port fitting. Slight revisions of the fitting geometry to maximize contact with the tank wall and optimize weldability would also add to the integrity of this welded joint. A thicker inner tank wall also would increase the weldability and strength of the weld joint and could assist in ensuring that a pressure relief system activated prior to implosion of the inner tank wall. It is not only feasible to incorporate a second outer weld, but also cost effective since the additional weld would take only minutes if not seconds to complete. Optimization of a weld procedure for a second weld would be necessary and may require a slight increase in wall thickness of the inner vessel, but it is feasible to add such a weld and would significantly increase strength of the joint and mitigate the potential for the type of stress riser that led to the failure in the subject weld and result in a substantially safer product. The incremental cost of improving the weld to eliminate the previously discussed defects and/or adding a second weld would be negligible and on the order of a few dollars. Even if the thickness of the 20-inch-tall section of the inner tank wall thickness were increased by a factor of 2, the incremental cost per tank would be on the order of $50 or less based on current retail pricing for 304 stainless steel. This incremental cost would be less than 0.3% of the approximate $20,000 retail cost of the tank to the consumer. Optimization of design and fabrication and bulk material pricing would further reduce the cost differential of such improvements.

In the event this matter continues to move forward, I may conduct additional testing, analyses, and/or prepare physical models and/or demonstrative exhibits in response to

[87] 2020-10-05 Deposition of Buster Ingram 39:1-3, 41:17-42:6

Defendants claims and analysis or for the purpose of further evaluating, illustrating and explaining how the subject Chart Tank is intended to operate and the manner in which it failed.

Qualifications

I hold a B.S.E., M.S. and Ph.D. in Mechanical Engineering and Materials Science with a minor in Computer Science. I have over 35 years of experience as a forensic engineer having worked in the areas of failure analysis, materials science, product liability, accident reconstruction, computer aided engineering, modeling, simulation, and visualization. A copy of my curriculum vitae is attached as Appendix A.

Compensation

My firm currently charges $445 per hour for my time plus expenses. Deposition and trial related time is billed at $495 per hour.

Anand David Kasbekar, Ph.D.

11/6/2020
Date

Appendix A

Kasbekar Curriculum Vitae

Anand David Kasbekar, Ph.D.

Education

B.S.E.	Mechanical Engineering, Duke University 1985
M.S.	Mechanical Engineering and Material Science, Duke University 1987
Ph.D.	Mechanical Engineering and Material Science with a Minor in Computer Science, Duke University 1994

Qualifications

Dr. Kasbekar's area of expertise is in the field of Mechanical Engineering and Materials Science with an emphasis on accident investigation, failure analysis, safe product design, computer simulation and 3D-visualization. His graduate research concentrated on the development of a nondestructive materials characterization technique which can be used to analyze defects in both metals and polymers at sub-microscopic levels. Dr. Kasbekar's research was funded by the Army Research Office. As part of this research, Dr. Kasbekar implemented a computer controlled system for thermal control and automated data collection. He has also conducted research involving low angle X-ray diffraction, thermal analysis, and mechanical testing to evaluate both metallic and polymeric components.

As a consultant with Research Engineers, Inc. (REI) since 1987, Dr. Kasbekar has worked in the areas of forensic engineering, materials characterization, product liability, and failure analysis. Currently, Dr. Kasbekar serves as President of Visual Sciences, Inc. (VSI) and has over 30 years of experience in the application of computer simulation and scientific visualization to the field of forensic engineering. This experience includes 3-dimensional computer modeling, photogrammetry, computer-aided accident reconstruction, computer imaging, finite element analysis and simulation of dynamic systems. Dr. Kasbekar has applied his computer expertise to the areas of accident reconstruction, failure analysis, safe product design, and human factors studies.

In addition to his work with VSI and REI, Dr. Kasbekar has served as an Adjunct Assistant Professor in the Department of Mechanical Engineering and Materials Science at The Duke University School of Engineering since 1995. He has also served on the executive committee and as President of the Duke University Engineering Alumni Council. He has served on the governing board for the Society of Automotive Engineers as the Vice-Chair of Math & Science for the North Carolina Section. Dr. Kasbekar has been the Principal Investigator and Research Scientist for multiple research and development contracts that have been awarded to Visual Sciences, Inc. by the United States Department of Defense.

Relevant Experience and Post Graduate Training

- Failure Analysis of Metals and Plastics
- Finite Element Modeling and Analysis
- Accident Reconstruction
- Photogrammetry
- Defect and Failure Analysis of Automotive Components
- Machine Guarding and Safe Product Design
- Materials Characterization and Testing
- Computer Simulation and Animation
- Perceptual Discrepancies in Color Production
- State-of-the-Art Data Visualization
- Physically Based Modeling
- Particle System Modeling
- Computer Graphics in Visual Effects
- Procedural Modeling and Rendering Techniques
- Recent Techniques in Human Modeling, Animation and Rendering
- Anthropometry and Laser Scanning of Humans
- UNIX, IRIX, VMS, DOS, Windows, and Macintosh Operating Systems
- The Effect of Impact and Other Rapid Loading Mechanisms on Plastics
- Polymer Degradation, Stabilization, and Failure Analysis
- Plastic Component Failure Analysis
- Failure Analysis of Plastic and Rubber Materials
- Environmental Stress Cracking and Other Solvent Effects
- Properties and Failure Mechanisms of Polycarbonate
- Preventing Plastic-Product Failures
- Advance Polymer Testing DEA
- Polymer Analysis from Raw Material to Formulation
- 3D Metrology in QA and Reverse Engineering
- 3D Laser Scanning for Boatbuilding

Professional Experience

Principal: Visual Sciences, Inc., Raleigh, NC (1995-Present): Directs all aspects of the Computer Visualization Laboratory. Specializing in the application of computer visualization and simulation to solve problems in the fields of science and engineering.

Consultant: Research Engineers, Inc., Raleigh, NC (1987-Present): Works as a forensic engineer in the areas of accident reconstruction, failure analysis, safe product design, and human factors studies. Developed and directed the Computer Visualization Laboratory for Research Engineers.

Assistant Adjunct Professor: Duke University School of Engineering, Department of Mechanical Engineering and Materials Science, Durham, NC (1995): Responsibilities included research, teaching, laboratory work, application of computer simulation and visualization technology to failure analysis case studies.

Contract Research Consultant: Battelle Memorial Institute, Columbus, OH (1993): Developed computer simulation model to analyze dynamic failure modes of proprietary thermal cut-off devices for electrical components.

System Administrator: Department of Mechanical Engineering and Materials Science, Duke University (1986-1987): Hardware and software management for DEC MicroVax II, Macintosh and DOS based computers; systems integration; and development of data acquisition and analysis programs.

Engineer: MPR Associates, Washington, D.C. (1986): Developed course in metallurgy and failure analysis for engineers; conducted failure analysis and defect analysis of metallic components primarily for naval and power generation equipment.

Research and Teaching Assistant: Department of Mechanical Engineering and Materials Science, Duke University (1984-1986). Conducted research in the area of materials science, failure analysis, and polymer characterization; laboratory instructor and teaching assistant for Failure Analysis and Materials Science classes.

Engineering Assistant: Federal Emergency Management Testing Facility, Naval Yard, Washington, D.C. (1983). Designed, prototyped, fabricated and tested equipment to manufacture and evaluate cumulative radiation dosimeters.

Supervisor: Department of Transportation, Duke University (1982-1986). Responsibilities included driver training, supervision, and scheduling of transportation personnel; basic fleet maintenance and repair scheduling.

Professional Societies

American Society of Mechanical Engineers
ASM The Materials Information Society
American Society of Safety Engineers
Society of Automotive Engineers
Association for Computing Machinery
Society of Plastics Engineers
National Society of Professional Engineers (Past Member)
National Computer Graphics Association (Past Member)
The Metallurgy Society (Past Member)
National Safety Council (Past Member)

Honors

Dean's List 4 years
Class Honors 4 years
Pi Tau Sigma International Mechanical Engineering Honor Society
Tau Beta Pi Engineering Honor Society
Graduated Magna Cum Laude
Graduated with Departmental Distinction
Research and Teaching Award for Graduate Study
Awarded Plastics Institute of America Fellowship

Major Research Awards, Seminars, and Publications

"Modeling Integrated Helmets for Aviation", Research Contract, US Department of Defense, 2003.

"Pressure Sensing Headforms", Research Contract, US Department of Defense, 2000.

"A Dynamic Model for Design Optimization of Protective Masks", Research Contract, US Department of Defense, 1997.

"High Technology and Construction: Tools for the Millennium
Forensic Applications of Three-Dimensional Computer Simulation & Visualization."
North Carolina Bar Association, Durham, NC 1998 (Invited Speaker).

"The Use of Computer Simulation and Visualization as a Forensic Engineering Tool", The Americans Inns of Court, Duke University School of Law, Durham, NC 1996 (Invited Speaker).

"The Application of 3-dimensional Computer Simulation & Visualization to the Fields of Accident Reconstruction and Forensic Engineering." Tennessee Defense Lawyers Association, Nashville, TN, 1995 (Invited Speaker).

"Seeing is Believing: Winning Your Case Through the Use of Computer Simulation." Stark County Academy of Trial Lawyers Fall Seminar, Akron, OH, 1994 (Invited Speaker).

"Computer Simulation and Visualization as an Engineering Tool." Joint Meeting of the North Carolina Chapter of the Society of Automotive Engineers and American Society of Mechanical Engineers, Raleigh, NC, 1994 (Invited Speaker).

"Fundamentals of 3D Computer Animation." Alliance Training Consortium, Raleigh, NC, 1993 (Instructor).

"State-of-the-Art in Accident Reconstruction and Computer Aided Simulation/Animation." West Virginia Trial Lawyers Mid-Winter Seminar, Charleston, WV, 1991 (Invited Speaker).

"Computer Simulation and Visualization." Panel on Multimedia, MacWorld Exposition, Boston, MA, 1989 (Invited Speaker).

Kasbekar, A.D. "A Positron Annihilation Lifetime Study of The Effects of Molecular Weight On Thermal Response and Free Volume Relaxation in Polystyrene." M.S. Thesis, Duke University Department of Mechanical Engineering and Materials Science, Durham, NC, 1987.

Kasbekar, A.D., P.J. Jones, and A. Crowson. "Positron Annihilation Lifetime Evaluation of Thermal Cycling Effects in Atactic Polystyrene." Journal of Polymer Science: Part A: Polymer Chemistry, 27 (1989): 1373-1382.

Kasbekar, A.D., P.J. Jones, and A. Crowson. "A Positron Annihilation Lifetime Study of Thermal Response and Isothermal Relaxation in Atactic Polystyrene." 8th International Conference On Positron Annihilation. Ed. L. Dorikens-Vanpraet, M. Dorikens and D. Segers. Gent Belgium: World Scientific, 1988.

Kasbekar, A.D. "A Positron Annihilation Lifetime Study of Crosslinked Polystyrenes and Sequential Polystyrene/Polystyrene Interpenetrating Polymer Networks." Ph.D. Dissertation, Duke University Department of Mechanical Engineering and Materials Science, Durham, NC, 1994.

Testimony of Anand David Kasbekar, Ph.D.		
January 13, 2014	Fairlawn Enterprices, LLC v IES Commercial Inc. a Newcomb Electric	Commonwealth of Virginia In the Circuit Court of the City of Roanoke
February 6, 2014	Bruce v CAV International, et al	In the Circuit Court of Cook County, Illinois
February 11, 2014	Linda Taylor, Phillip Taylor and Elizabeth Van Pelt Vs Sportsman's Outfitters & Marine, Inc.	In the Circuit Court of Macon County State of Missouri
February 18, 2014	Daniel Dobson, et al. vs Renee Wade, et a.	In the Circuit Court of the 19th Judicial Circuit, in and for St. Lucie County, Florida
March 11, 2014	Townsend v NCDOT	North Carolina Industrial Commission
May 15, 2014	Dorman vs Atmos Energy	In the Circuit Court of the City of Richmond
July 29, 2014	Miller vs Richard Allen Gaddy, Blue Max Trucking, et al	State of North Carolina County of Mecklenberg
August 21, 2014	Bruno Vono vs Paul H. Angier and John K. Wolfe	In the Circuit Court of the Seventeenth Judicial Circuit in and for Broward County, FL
August 29, 2014	Dorman vs Atmos Energy	In the Circuit Court of the City of Richmond
September 9, 2014	Townsend v NCDOT	North Carolina Industrial Commission
September 12, 2014	Townsend v NCDOT	North Carolina Industrial Commission
September 25, 2014	Vollman Nicholaus vs Middlesex Corporation	In the Circuit Court of the Ninth Judicial Circuit, in and for Orange County, FL
October 24, 2014	Bruno Vono vs Paul H. Angier and John K. Wolfe	In the Circuit Court of the Seventeenth Judicial Circuit in and for Broward County, FL

October 29, 2014	Bruno Vono vs Paul H. Angier and John K. Wolfe	In the Circuit Court of the Seventeenth Judicial Circuit in and for Broward County, FL
May 20, 2015	Lois Huffman et al. vs City of Marion, OH	In the Court of Common Pleas of Marion County, OH
June 9, 2015	Debra Jane Pipps, et al vs Robert O'Neal McCants, et al.	State of South Carolina Court of Common Pleas County of Horry Fifteenth Judicial Circuit
June 15, 2015	Micron Technology v Safway Services, Inc. and Robert Aquino	Virginia - In the Circuit Court for the City of Alexandria
August 7, 2015	Kawasaki Motors Manufacturing, et al. vs ITW Fastex-CVA, et al.	In the Circuit Court of Jackson County, Missouri at Independence
August 21, 2015	The Estate of Peter Paul Faust, et al. vs Strata Corporation, et al.	In the United States District Court for the District of Montana Billings Division
November 17, 2015	Hickerson vs Yamaha Motor Corp., et al.	United States District Court District of South Carolina Anderson Division
February 2, 2016	Quentin Ravizza vs PACCAR, Inc & Kenworth Truck, Co.	In the United States District Court Northern District of Illinois Eastern Division
February 5, 2016	Tracy Sanborn and Louis Lucrezia vs Nissan North America, Inc.	United States District Court Southern District of Florida
February 25, 2016	Lesley Marbeth Derrick, deceased vs. Berlin G. Myers Lumber Corp., and Daniel Patrick Siebert	In the Court of Common Pleas for the State of South Carolina Dorchester County

March 3, 2016	H.J. Heinz Company vs. Atlantic Aviation FBO Holdings, LLC and Mercury Air Center – Nashville, LLC Global Aerospace, Inc., vs. Atlantic Aviation FBO Holdings, LLC and Mercury Air Center – Nashville, LLC	In the Circuit Court for Davidson, Tennessee at Nashville
May 3, 2016	Carolyn Thomson and Aaron Hoylk vs. Spokane County, a municipal corp, Spokane County Sheriff's Dept., and Joseph Bodman	In the Superior Court of the State of Washington in and for the County of Spokane
April 26, 2017	Melinda S. Spratt, Plaintiff vs. TREK Bicycle Corporation, Defendant	In the Superior Court of Cobb County State of Georgia
May 17, 2017	Barlow vs The Cook Group, Galleon Resort at Key West	In the Circuit Court of the Eleventh Judicial Circuit in and for Miami-Dade County, Florida
June 6, 2017	Quentin Ravizza vs PACCAR, Inc & Kenworth Truck, Co.	In the United States District Court Northern District of Illinois Eastern Division
June 19, 2017	Quentin Ravizza vs PACCAR, Inc & Kenworth Truck, Co.	In the United States District Court Northern District of Illinois Eastern Division
August 29, 2017	Billy Jo Humphries v. JLG Industries, Inc.	In the United States District Court For The Eastern District of Virginia
November 20, 2017	Whynot vs Publix	In the Circuit Court of the Ninth Judicial Circuit in and for Orange County, Florida Division 35
January 25, 2018	Tribble vs Warwood Tool Company	In the United States District Court for the Western District of Virginia Lynchburg Division

April 27, 2018	Rider vs Kawasaki Motors, Corp	In the United States District Court District of Utah, Central Division
July 31, 2018	Bennie Wood and Linda Wood vs Navistar, et al.	In the Circuit Court of Cook County, Illinois County Department, Law Division
November 2, 2018	Laura Frances Hays vs Nissan North America Inc., Nissan Motors Company, LTD.	In the United States District Court for the Western District of Missouri Western Division
November 13, 2018	Bennie Wood and Linda Wood vs Navistar, et al.	In the Circuit Court of Cook County, Illinois County Department, Law Division
December 14, 2018	Rider vs Kawasaki Motors, Corp	In the United States District Court District of Utah, Central Division